Method of Calculation of Crown Wall Stability in Oblique Waves

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Method of calculation of crown wall stability in oblique waves

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1. Introduction

The wave loading along a structure exposed to oblique waves varies in time and space. Despite of this, the wave generated pressures are usually recorded by gauges only in one position of the wall (more gauges densily spaced is regarded as one position).

Because of the variation in instantaneous loading along the wall it will be too much on the safe side to use the maximum recorded loading in the design. Instead should be estimated and used the maximum instantaneous critical loading over the total length LC of the monolithic crown wall section. The larger LC, the smaller will be the average loading per metre of wall and the necessary the volume of the structure. This aspect should be considered in the design.

Fig. 1 shows the situation with oblique waves of local wave length L and angle of incidence α hitting the wall. The celerity of the waves is $v = L/T$, where T is the wave period. The velocity of the wave formation along the wall is $v/\sin\alpha$.

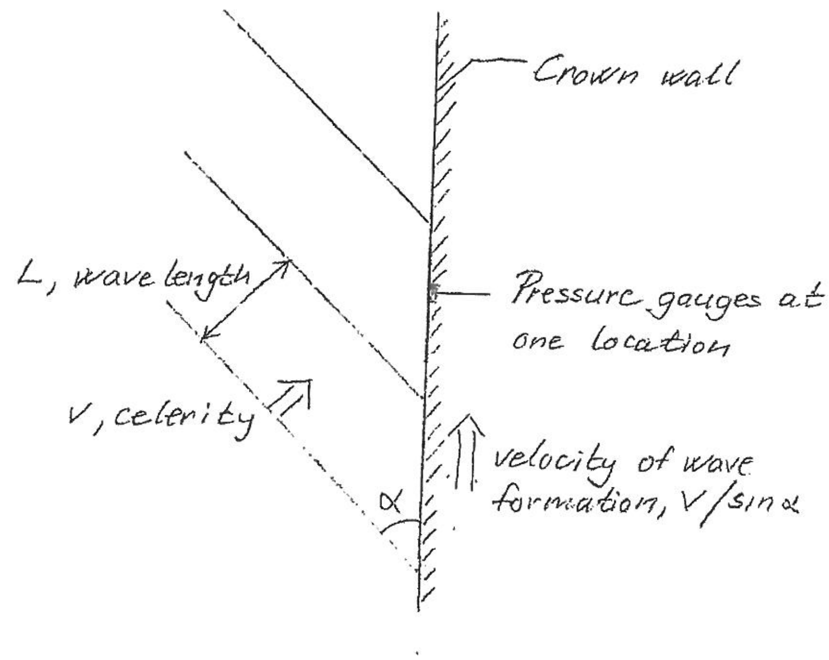

Fig. 1. Oblique waves on wall

2. Basic hypothesis

It is assumed that exactly the same pressures as recorded in one position are acting also in all other positions along the wall, but in different times as the wave form travels along. Based on this quite realistic assumption it is possible to convert the high frequency point pressure recordings to equivalent simultaneous along-structure pressures.

3. Estimation of wave loading along the structure

Fig. 2 illustrates the method which is simply a convertion of recordings of forces and moments at time interval Δt (frequency 1/Δt) to equivalent travelling distance $\Delta l = \Delta t\, v / \sin\alpha = \Delta t \frac{L}{T} \frac{1}{\sin\alpha}$.

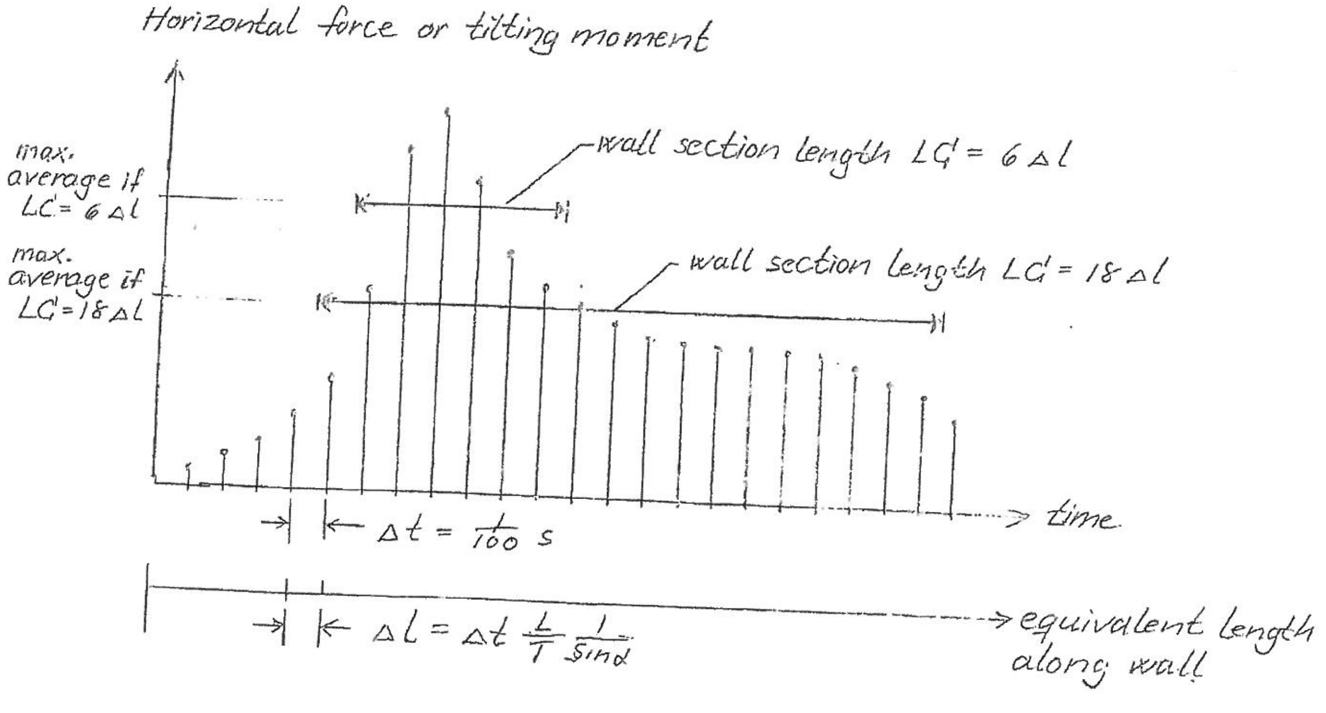

Fig. 2. Illustration of convertion of locally recorded loadings to spatially distributed instant loadings

The maximum average value of the loadings over the length LC of the crown wall must be identified by a running average procedure, and subsequently used in the stability analyses.

4. Choice of wave input parameter values and averaging.

The larger Δl, the larger the average loading over a given wall section length. For this reason it is suggested to use larger but realistic values of L/T. In the case of the INHA Model 2 with waves of Tp = 20s and max water depth at the toe of the structure of app. 16m, L/T is app. 12 m/s. With a model length scale 1:60 and a pressure sampling rate of 100 Hz then in prototype

$\Delta t = (60)^{0.5}/100 = 0.0775s$. With α = app. 45° we get in prototype value Δl = app. 1.3m.

If, as an example, the length of the monolithic crown wall section is in the interval 5m < LC < 15m, then the max. average loading should be identified by averaging over app. 4 to 12 consecutive pressure recordings.

The crown wall is usually cast in shorter sections. Despite this the crown wall can act as a much longer monolithic structure against *sliding* if simple shear keys are provided in the joints between the sections. Provision of torsion keys against tilting is much more difficult and generally not feasible.

5. Design of crown wall

The geometry should – apart from the crest and base levels – be tuned to the loadings identified in accordance with the method given above. It is important to realize that design is a 3-dimensional problem in this case with many options for the geometry and savings. The UTE-Langosteira should in the first hand specify their wishes to the construction procedure and their planned concrete casting capacity.

6. Integration of recorded pressures to wave loadings

With more pressure gauges arranged close to each other the pressures to apply should be the average for each level of the pressure gauges.

Pressures at corners where for space limitations gauges could not be installed, are usually estimated by extrapolation from the two nearest pressure gauges. This procedure needs visual checking in order to avoid unrealistic results. For example, at the crest of the wall the wave generated pressure is zero. At the foot corner of the wall, there is never a substantial pressure increase with depth. However, the faulty estimates caused by the extrapolation will more or less disappear when the method given above is used, simply because of the averaging over several consequent recordings.

Moreover, the difficult question of using the absolute highest pressure values (which increase with sampling frequency) is also solved by the method.

I recommend the uplift pressure to be taken as a triangle although it assumes that the pressure at the rear end of the base is zero. This might actually not be the case as we are dealing with the long waves and maybe a somewhat permeable upper core. On the other hand, the triangular shape is on the safe side in case of homogeneous core material, so in conclusion the triangular shape can be defended and is probably on the safe side.